7th Integrated CNS Conference

L-Band Commercial Communications Service for Unmanned Aircraft Systems

Tom Mulkerin

May 3, 2007

7405 Alban Station Ct., Suite B-201, Springfield, VA 22150-2318 (703) 644-5660

Content

- **Background**
- **Unmanned Aircraft System Description**
- **Communications Service Provider**
- **ATC Communications Link**
- **Control Link**
- **Conclusion**

Background

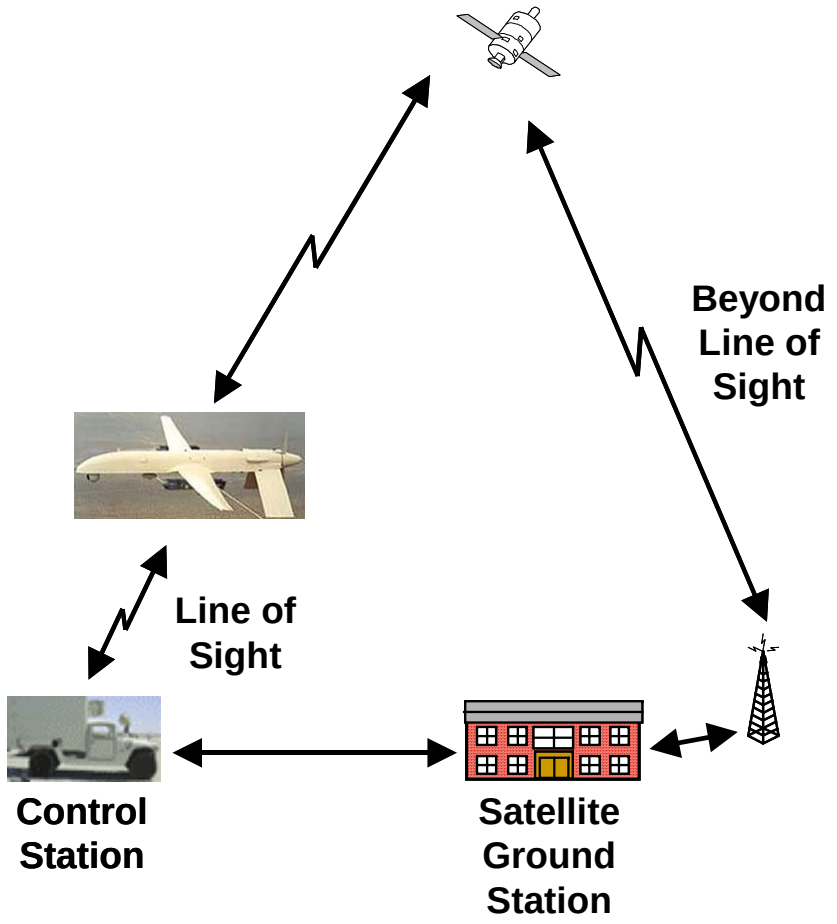
- **Unmanned Aircraft (UA) have evolved significantly from their first use over 90 years ago.**
  - **Flying bombs during World War I**
- **Radio controlled model aircraft also have been around for a long time**
  - **Initially used by hobbyists**
  - **Entrepreneurs are finding commercial uses; e.g., aerial photography of real estate and farmland**
  - **Usage could be extended to provide traffic video during rush hours in metropolitan areas**

Background

- **Why aren't UAs providing rush hour traffic video today?**
  - **A one-word answer - "safety"**
  - **UAs must be segregated from other aircraft in the National Airspace System (NAS) until they can be shown to not be a hazard to other aircraft.**
  - **UAs that are providing border security fly within Temporary Flight Restricted (TFR) areas because not equipped to avoid other aircraft**
- **Solution - Build unmanned aircraft systems that have a demonstrated capability to safely fly near manned aircraft**
- **Goal - For an unmanned aircraft to be able to file a flight plan and fly in the NAS with no more restrictions than those imposed on a manned aircraft**

Unmanned Aircraft System

- **What is a UAS?**
  - **Aircraft segment**
  - **Control segment**
  - **Communications segment**



Unmanned Aircraft

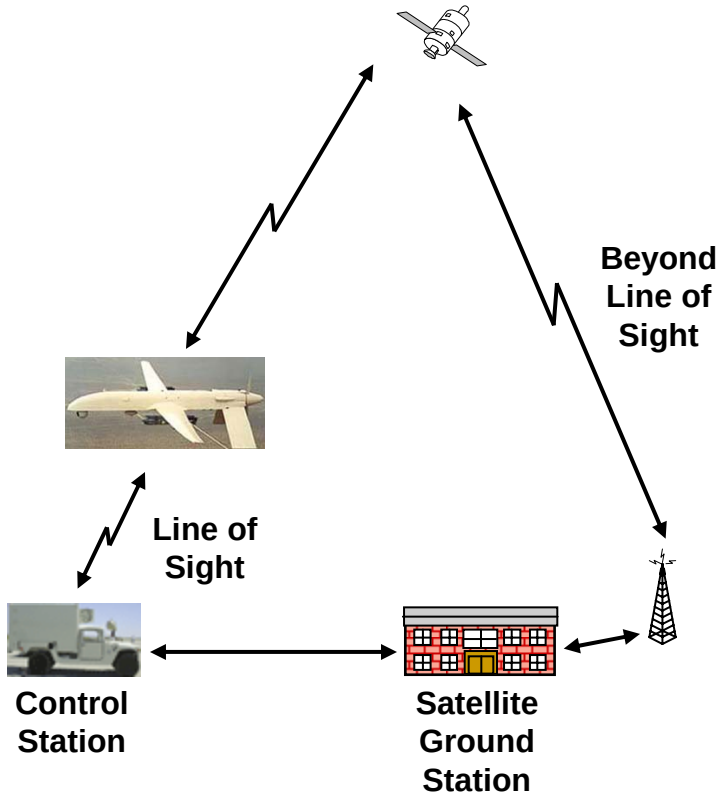
- **UAs come in all sizes and levels of automation – model airplane to the Global Hawk**
- **Level of flight control automation built into the aircraft varies**
  - **Flight control surfaces on very small aircraft are generally controlled by the pilot**
  - **Many of the large aircraft are semi or fully automated.**
- **Key component is the communications equipment**
  - **Aircraft sends telemetry data to the control station**
  - **Aircraft receives commands from the control station**
  - **UAs under FAA control may relay the controller's transmissions to the pilot and the pilot's transmissions to the controller**

Control Station

- **Set of equipment used to control the flight of the UA**
- **Pilot's location**
- **Vary in size: handheld device => room full of electronic and communications equipment**
- **Provides pilot ⇔ aircraft communications means**
- **Supports two-way telemetry/command link with aircraft**
- **May support ATC voice/data link**

LOS and BLOS Communications

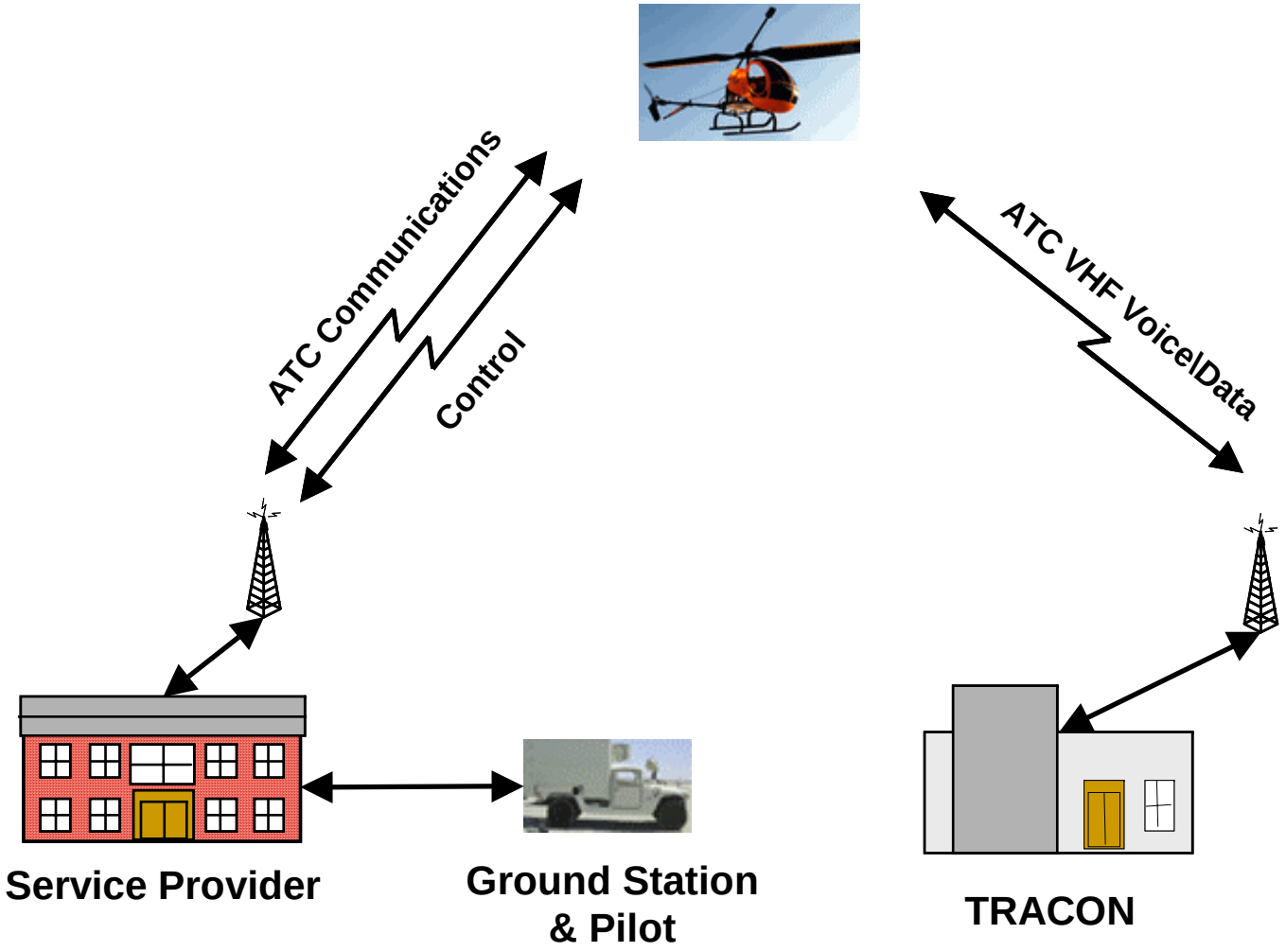
- **Line of sight (LOS) communications means a direct path between the transmitting and receiving antennas**
- **Beyond line of sight (BLOS) communications means that a relay radio is employed**
  - **Relay is usually a satellite for aviation**



UAS Communications System Proposal

- **Commercial organization would provide UAS users with communications services**
  - **Proposal based on the FAA making part of the 960 - 1024 MHz spectrum available to the service provider**
  - **960 - 1024 MHz band is in protected aviation spectrum**
  - **Provide UAS users with the communications path from the control station to the UA**
    - **ATC Communications Link(s) for ATC VHF voice/data relay from the UA to the pilot and pilot to UA**
    - **Control Link for telemetry and command communications**
  - **Nationwide service available to subscribers**

Unmanned Aircraft Communications Paths



Communications Link Access

- **Service provider would establish a network of access points through which a UAS control station could establish communications with its UA.**
- **Network design left to the service provider**
  - **Network must meet Required Communications Performance (RCP) requirements adopted by the FAA for safe UAS operations**
- **Principal connectivity method between control station and service provider will probably be via landline**
  - **Most likely a dedicated circuit**
  - **Dialup circuit acceptable if it can meet the FAA's RCP requirements for latency, integrity and availability**

Protocols

- **Service provider would define the physical and link layer protocols**
- **Users would have the flexibility to use proprietary protocols above the link layer**

Service Provider's Network

- **Provide LOS communications**
- **Multiple transmitters and receivers**
- **Potential algorithm for selecting the transmitting site**
  - **Multiple ground stations might receive a UA's transmissions**
  - **Best signal would be routed to the control station**
  - **System select the site that received the best signal for transmissions**

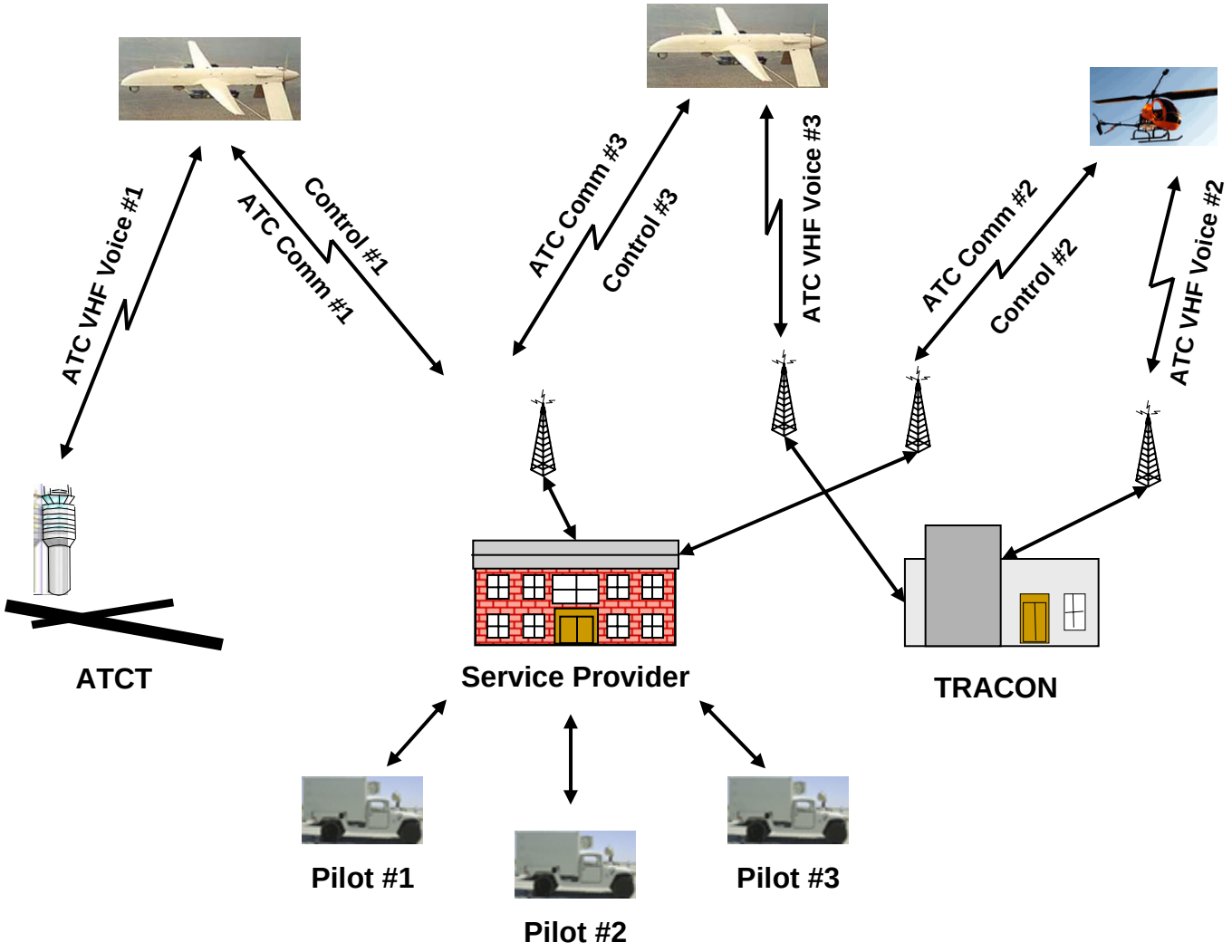
ATC Communications Link

- **Initially carry VHF voice between ATC controller and pilot**
- **Later, carry Controller Pilot Data Link Communications (CPDLC) messages**
- **Support ATC Voice**
  - **Voice transmissions received by the UA on a VHF radio**
  - **Relay the transmission to the pilot at the control station via the ATC Communications link**
  - **UA would carry a standard, certified VHF voice radio**
  - **Additional equipment on the UA would convert VHF radio's analog voice signal to digital and transmit on ATC Communications link**
  - **Equipment would convert digitized voice from pilot on the ATC Communications link to analog and rebroadcast it over the VHF radio**

ATC Communications Link

- **Multiple UAs operating in the same TRACON will be directed by different controllers**
  - **Service provider's system must relay transmissions for each controller VHF voice frequency**
  - **Could mean a separate ATC Communications link for each ATC controller**
- **The same link might be used for both controller-to-pilot communications and telemetry/command data**
  - **Latency requirements for ATC Communications and Control link data will determine whether the link can be shared**
  - **Possibility of sharing the link increases as the FAA transitions from voice to data link for ATC functions**

Multiple UAs Operating in the Same Area



ATC Voice Communications

- **What are the voice communications requirements?**
  - **Yet to be defined**
  - **FAA's Next Generation Air/Ground Communications System (NEXCOM) may be close to those for a UAS**
  - **NEXCOM VHF radio had a digital voice channel designed for ATC voice communications**
- **NEXCOM voice circuit availability requirement is 99.999%**
- **NEXCOM voice communications latency requirements are shown below**

Path	Latency (95%)
Controller to Pilot	0.55 sec
Pilot to Controller	0.22 sec
Two-way	0.77 sec

ATC Communications Link

- **Support ATC Data Link**
  - **FAA is moving towards using data link as the primary means of communications in performance-based airspace**
  - **ATC Communications link would support exchange of CPDLC messages**
  - **VHF Digital Link - Mode 2 (VDL-2) will probably be the protocol used by the FAA**
  - **UA would carry certified VHF data radio**
  - **UA would have equipment needed to convert messages between the CPDLC and ATC Communications radios**
- **Significantly more bandwidth needed to relay voice than CPDLC**

ATC Communications Link

- **FAA transition from voice to data link will be implemented in three segments**
  - **Segment 2 starts in 2017**
  - **Aircraft must be data communications equipped for access to performance-based airspace**
- **Link availability requirement: 99.999%**
- **95th percentile one-way transit times shown below**

Domain	Threshold	Objective
En Route	3.0 sec	1.5 sec
Tower	3.0 sec	1.5 sec
Terminal	3.0 sec	1.5 sec

Control Link

- **Supports two-way communications associated with flying the aircraft**
- **Carries command and telemetry data**
  - **Data generated by detect, sense and avoid avionics is a subset of telemetry data**
- **Bandwidth requirement will depend upon the level of autonomy needed to fly the UA**
  - **Link load for a UA that only accepts waypoint changes is significantly less than for a UA receiving control surface commands**
- **Required Communications Performance (RCP) for highly autonomous UA will be less stringent than for UA which needs control surface commands from its control station**

Control Link

- **RCP requirements for highly autonomous UAs may be similar to those for data linked ATC commands**
  - **Changing flight path by transmitting new waypoints is similar to controller directing an aircraft via data link to change its heading**
  - **95th percentile one-way transit times**
    - **Threshold: 3 sec**
    - **Objective: 1.5 sec**
- **More stringent latency requirements for UA with little autonomy**
  - **Specific requirements to be determined**
  - **Requirements will probably vary by flight domain**
  - **Most stringent requirements may be on the order of 200 ms or less**
- **Availability requirement probably independent of automation level**
  - **Likely to be 99.999%**

Conclusion

- **Commercial service in L-Band could be part of the solution for providing the communications needed by UAs to fly safely in the NAS**

Contact

Tom Mulkerin
Mulkerin Associates Inc.
7405 Alban Station Ct., Suite B-201
Springfield, VA 22150-2318
(703) 644-5660
Tom.Mulkerin@Mulkerin.com